ARL

US Army Research Laboratory

VO2sim 0.1: Using Simulation to Understand Measurement Error in Indirect Calorimetry

by Matthew S Tenan

NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of manufacturer's or trade names does not constitute an official endorsement or approval of the use thereof.

Destroy this report when it is no longer needed. Do not return it to the originator.

US Army Research Laboratory

VO2sim 0.1: Using Simulation to Understand Measurement Error in Indirect Calorimetry

by Matthew S Tenan
Human Research and Engineering Directorate, ARL

REPORT DOCUMENTATION PAGE			*Form Approved* OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection information Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302 Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED (From - To)
August 2015	Final	1 February 2015–26 May 2015

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
VO2sim 0.1: Using Simulation to Understand Measurement Error in Indirect Calorimetry	
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	5d. PROJECT NUMBER
Matthew S Tenan	
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
US Army Research Laboratory ATTN: RDRL-HRS-B Aberdeen Proving Ground, MD 21005-5425	ARL-TR-7384

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Indirect calorimetry is commonly used in military research to examine the energetic cost of exercise during various perturbations and as a risk factor for injury/illness. The Army has recognized the importance of understanding oxygen consumption in the field and is developing models to aid in operational decision making. A common study design within the Army and in other exercise applications is a test-retest design. Failure to control for expected variability in testing may lead researchers to conclude that an intervention is effective when their results are only a product of chance variability within the human or machine system. This report details the development of a simulation program that accounts for system and human variability to determine if 2 testing sessions are different.

15. SUBJECT TERMS

metabolic, indirect calorimetry, COSMED, VO_2, VCO_2, caloric expenditure, statistical simulation

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Matthew S Tenan
a. REPORT	b. ABSTRACT	c. THIS PAGE	UU	42	19b. TELEPHONE NUMBER (Include area code)
Unclassified	Unclassified	Unclassified			410-278-5884

Contents

List of Figures

1. Introduction

Indirect calorimetry is commonly used in military research to examine the energetic cost of exercise during various perturbations and as a risk factor for injury/illness. The US Army has used indirect calorimetry to determine the metabolic cost of using functional exoskeletons (Gregorczyk et al. 2006) and when comparing rucksack design (LaFiandra et al. 2003). Indirect calorimetry has also been used to understand how military personnel acclimatize to high altitude (Amann et al. 2013) and hypoxia (Self et al. 2013). The Army has recognized the importance of understanding oxygen consumption in the field and is developing models to aid in operational decision making (Weyand 2013). Decreasing the energetic cost, or caloric expenditure, of a task is important since it results in a decreased need to carry food as well as a lower likelihood of fatigue and injury (Mair et al. 1996; Gefen 2002; Borotikar et al. 2008).

Caloric expenditure was originally quantified via direct calorimetry where a subject exists within a room-sized module insulated by a water current. The heat given off by the body heats the water current and is measured to determine the energy expended by the body (Atwater and Benedict 1983). The cumbersome direct calorimetry method was later updated so that volumes of expired oxygen (VO_2) and carbon dioxide (VCO_2) can be measured to determine the caloric expenditure while subjects are engaged in activities outside a singular room (Weir 1949). These volumes are calculated by determining the total gas ventilation (VE), assuming a standard inspired gas ratio (20.95% O_2 and 0.03% CO_2) and assuming that gaseous nitrogen is inert (inspired N_2 = expired N_2); the expired fractions of O_2 and CO_2 determined by a metabolic system are then used to calculate VO_2 and VCO_2. This indirect calorimetry method has been further refined by advances in O_2 and CO_2 sensors and resulted in the present generation of mobile metabolic devices from a variety of manufacturers.

The most commonly used fully portable indirect calorimetry device is the Cosmed K4b[2]. This is the device presently in use at the US Army Research Laboratory's Human Research and Engineering Directorate. A common study design within the Army and in other exercise applications is a test–retest design. In this design, a Soldier will be tested under normal or control conditions and then tested again during experimental conditions. The difference observed between the control and experimental conditions is theoretically a direct result of the experimental perturbation. However, testing session variability at the individual physiologic level (e.g., dietary changes, diurnal hormonal oscillations) and at the level of the measuring device (e.g., O_2/CO_2 sensor variability, ambient air temperature,

barometric pressure) may obscure any minor changes due to the experimental intervention. Therefore, it is important to account for the variability expected between 2 identical "control" testing sessions when examining the result of an experimental trial. Failure to control for expected variability in testing may lead researchers to conclude that an intervention is effective when their results are only a product of chance variability within the human or machine system.

The author developed a computer program, VO2sim, to address the concern that nonuniform results in experimental trials may be a product of natural measurement variability. VO2sim 0.1 is a simulation tool to determine if the experimental calorimetry measurement is outside the range that would be expected for normal session-to-session variability (e.g., 100% chance experimental condition is higher than control condition). If the experimental measure is determined to be within session-to-session variability, a probability measure is returned, indicating the probability that the experimental value is higher or lower than the control measure (e.g., 60% chance that experimental value is lower than control value). The general purpose of VO2sim is to provide a probabilistic context for VE, VO_2, and VCO_2 measures that are commonly made within a test–retest study methodology.

2.   Methodology

VO2sim 0.1 is written in R 3.1.2 (R Core Team 2014), which is a free programming language for statistics and data science. The present iteration of VO2sim is valid only for the Cosmed $K4b^2$ system and uses previously published reliability data to determine the distribution of measurement error (Duffield et al. 2004; Darter et al. 2013). VO2sim is an umbrella term for 3 functions: *VO2sim.repeat*, *VCO2sim.repeat*, and *VEsim.repeat*, which assess the probability of real differences between the control and experimental conditions for VO_2, VCO_2, and VE, respectively (raw code for functions is available in Appendix A). The operational flow for each function is the same; *VO2sim.repeat* will be used as an example.

The control and experimental VO_2 measures (liters/minute) obtained at the same exercise workload are put into the function with the "cosmed_k4b2" indicated as the system that collected the data. The control volume and system are used as the means to create a random uniform distribution of 100,000 observations, where the maximum and minimum of the distribution are calculated based upon the intraclass correlation (ICC) for that volume. The formula for calculating the maximum and minimum of the distribution is *Distribution max/min = volume ± [(1 − ICC) × volume]*.

For example, a VO$_2$ measurement of 1.5 L/min has a repeatability ICC of 0.85 (Darter et al. 2013); therefore, a random uniform distribution between 1.275 and 1.725 is created from a control measurement of 1.5 L/min (Fig. 1). ICCs for session-to-session reliability differ depending upon the total volume of gas flow; therefore, the ICC differs for each system depending upon on the volume of gas measured. The random uniform distribution was selected in lieu of other distributions because previous research has demonstrated that session-to-session agreement follows a random uniform distribution (Crouter et al. 2006).
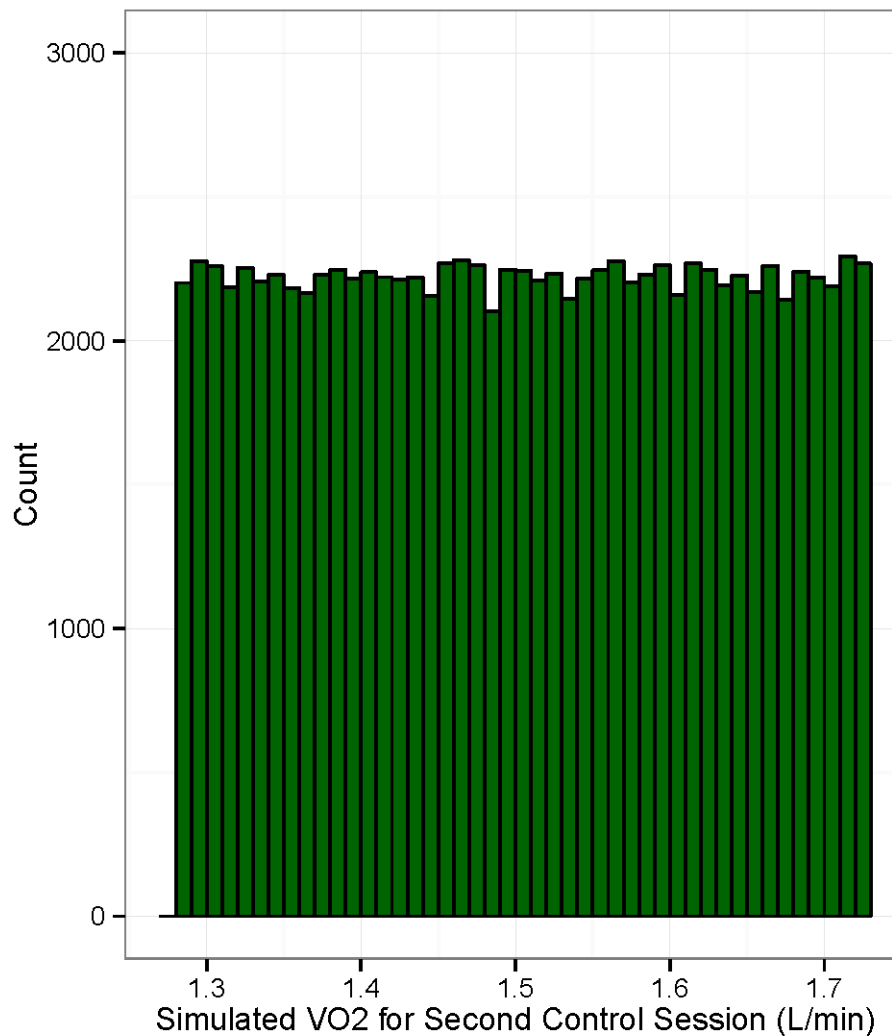
Fig. 1   Random uniform distribution with a mean of 1.5 L/min

The simulated distribution of expected values for a second control condition is then compared against the measured experimental session VO$_2$. If the experimental value falls outside of the distribution on the high end, it will return an output that there is a 100% probability that the experimental value is higher than the control value (Fig. 2). If the experimental value falls within the expected control distribution, it is determined whether the greatest number of samples in the distribution are higher (Fig. 3), lower (Fig. 4), or identical to the experimental value. The highest number of samples is calculated in ratio with the total samples in the distribution to determine the probability that the experimental value is higher, lower, or identical to the control value.
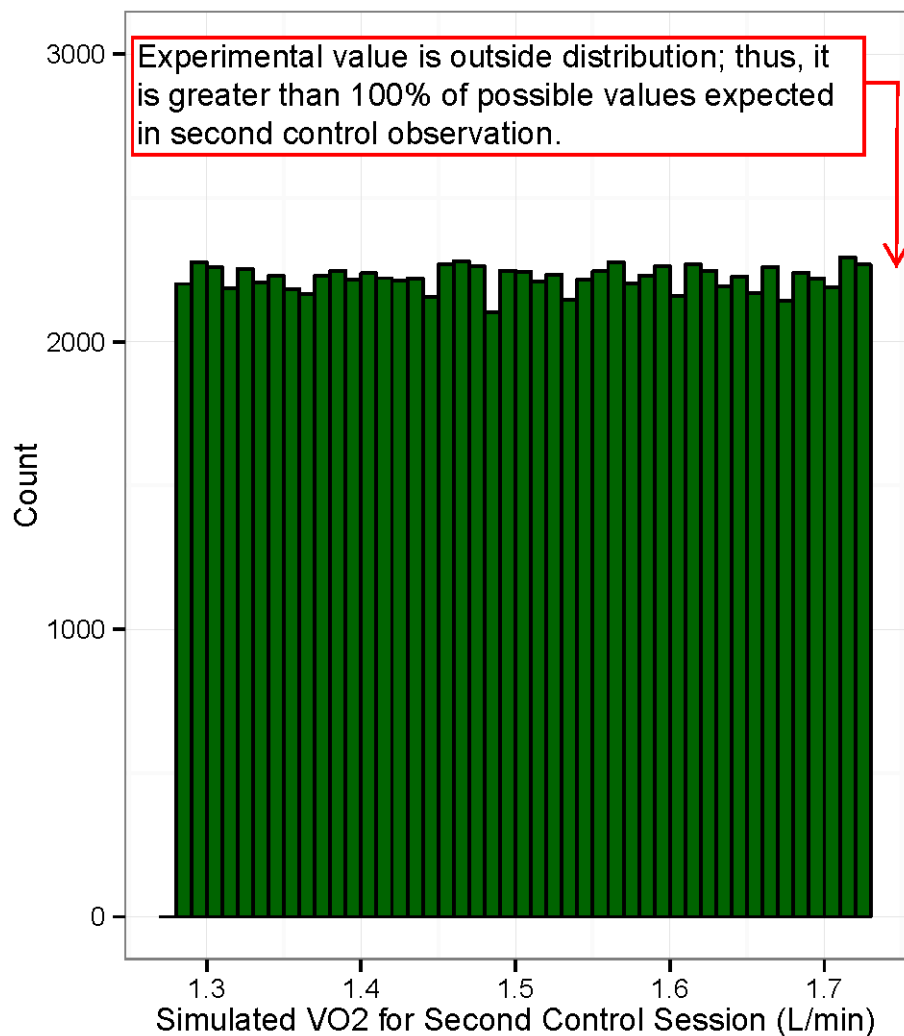
Fig. 2 Comparison of random uniform distribution to an experimental value falling outside the control distribution

4
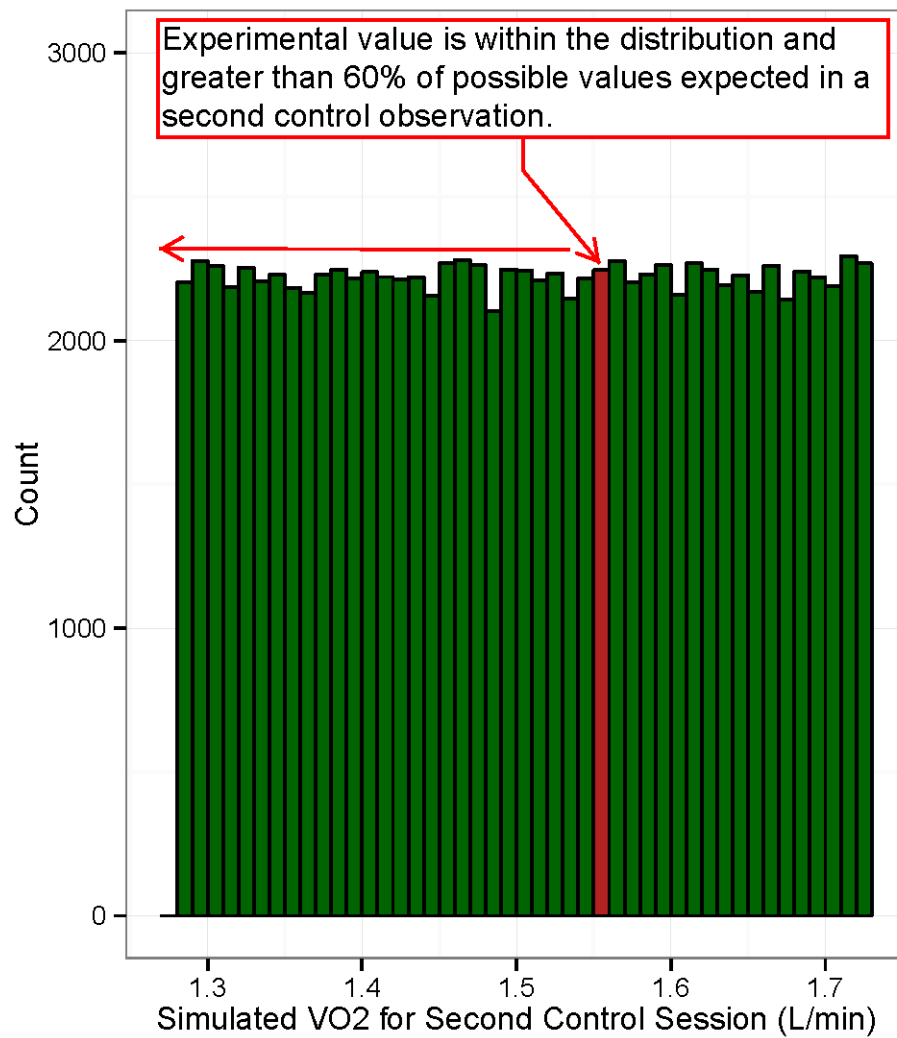
Fig. 3 Comparison of the random uniform distribution to a value that falls within the control distribution and where 60% of the control distribution is lower than the experimental value
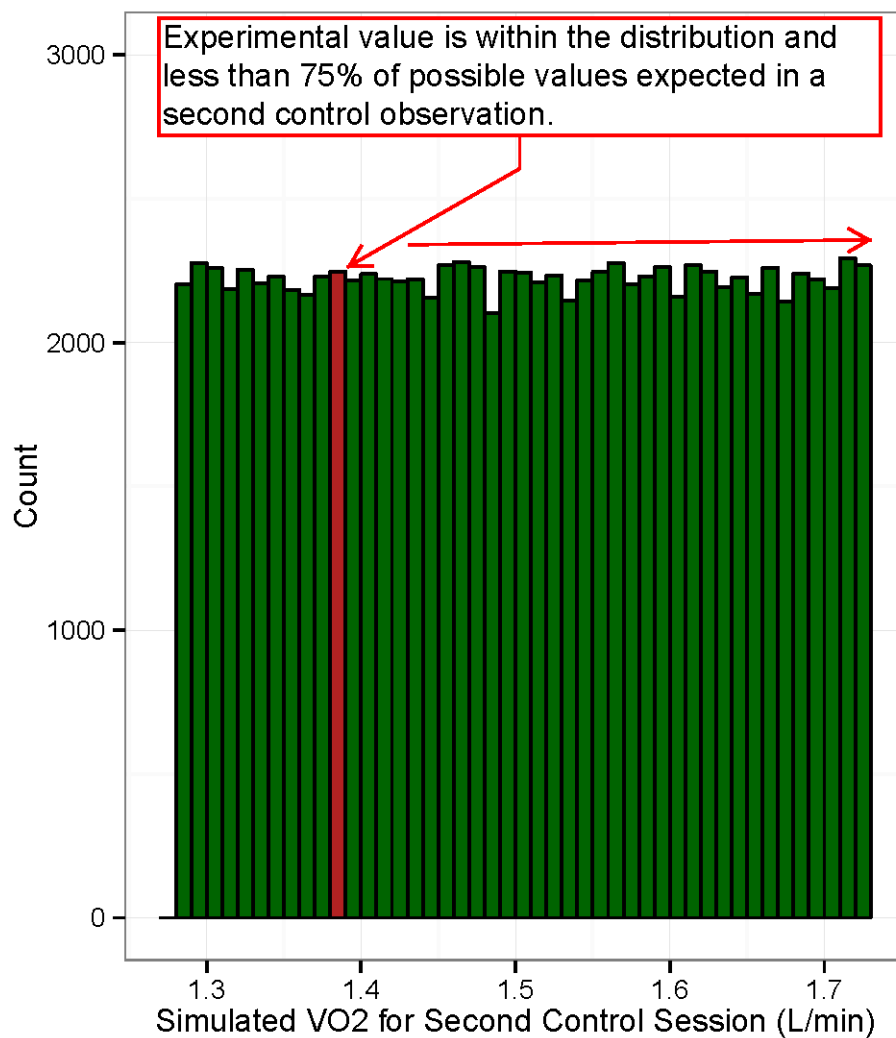
Fig. 4 Comparison of the random uniform distribution to a value that falls within the control distribution and where 75% of the control distribution is greater than the experimental value

2.1 Calling VO2sim 0.1 Functions

VO2sim.repeat is called with up to 3 arguments:

VO2sim.repeat(a, b, system = 'cosmed_k4b2')

Variable "a" is the control value and variable "b" is the experimental value. The default system is "cosmed_k4b2". In the current version of VO2sim, there is not presently support for other indirect calorimetry systems, so any other input will result in a system message indicating that the data are unable to be processed. Future versions of VO2sim will support other popular indirect calorimetry systems that have appropriate repeatability data available.

6

2.2 VO2sim 0.1 Results

The VO2sim.repeat function returns an object with 3 respective values:

- Probability that the measures are the same

- Probability that "b" is greater than "a"

- Probability that "b" is less than "a"

A string is also returned explaining which probability in the previous object is the largest. The string is designed to explain the primary findings of VO2sim for a single subject. The data in the object allow the researcher to aggregate VO2sim results from multiple subjects and return a "net probability difference" based upon the mean of the data from the column appropriate to their a priori hypothesis.

2.3 Calculating Difference Probability Curves

The benefit of having VO2sim functions contained within R allows for entire vectors of data to be analyzed with ease. Using simulated sequential data, curves can be constructed to demonstrate how a 3% (Fig. 5), 6% (Fig. 6), 10% (Fig. 7), and 15% (Fig. 8) measured increase in experimental VO2 result in the probability that it is actually greater than the control session. The implementation of these functions on simulated vectors for the creation of Figs. 5–8 is contained within Appendix B.
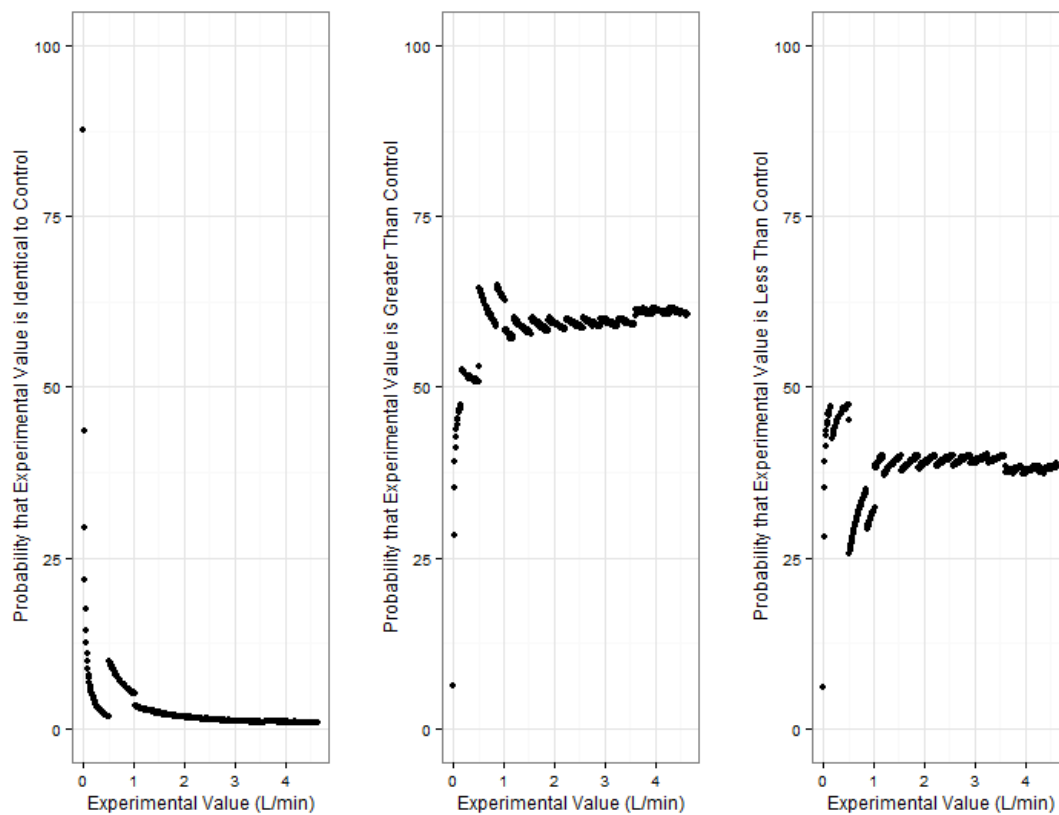
Fig. 5 VO2sim probabilities that experimental value is different from control when the experimental value is 3% higher than control
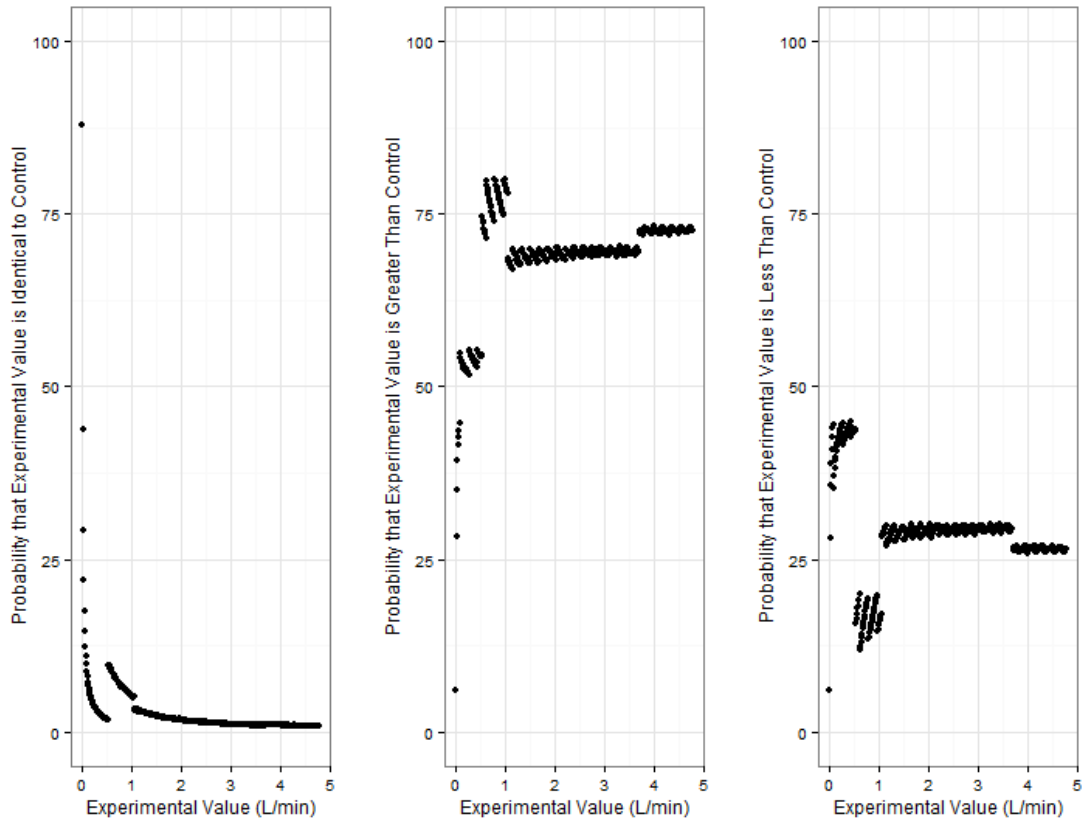
Fig. 6   VO2sim probabilities that experimental value is different from control when the experimental value is 6% higher than control
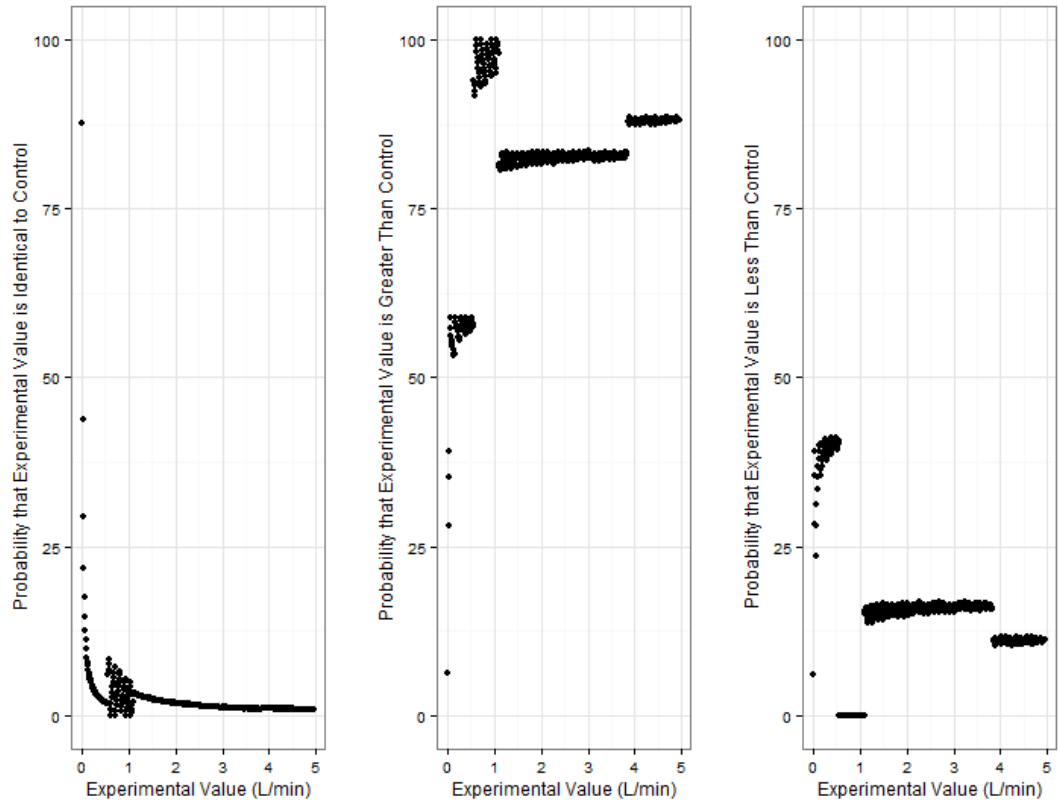
Fig. 7 VO2sim probabilities that experimental value is different from control when the experimental value is 10% higher than control
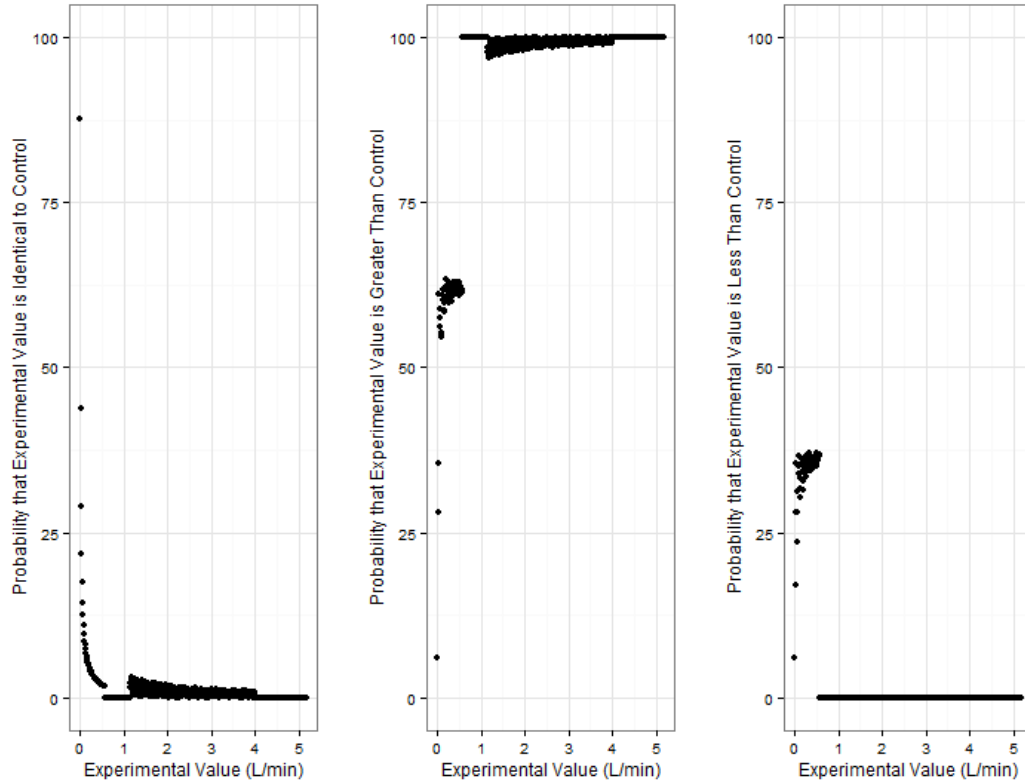
Fig. 8 VO2sim probabilities that experimental value is different from control when the experimental value is 15% higher than control

3. Discussion and Conclusions

VO2sim is designed to test the hypothesis that VO2, VCO2, and VE values from an experimental trial are either lower or higher than the control trial. To that end, it can be used in lieu of a standard statistical test for a single subject analysis. When data from more than one subject are obtained, best practice is to first use a repeated-measures t-test. If statistical significance of a 2-tailed test is obtained, a directional hypothesis should be made; the individual data for all subjects should be analyzed with VO2sim and a "net probability difference" can be calculated. Instances where statistical differences are achieved but the net probability of VO2sim difference is less than 85% should lead the researcher to interpret their results with heavy skepticism. The most conservative interpretation of the VO2sim output is that any difference probability less than 100% is not different between the 2 conditions. Proposed conventions for applying VO2sim are as follows:

- Experimental value definitely different from Control: 100%

- Experimental value probably different from Control: 85%–99%

- Experimental value unlikely to be different from Control: 70%–84%

- Experimental value not different from Control: Below 69%

The probability curves (Figs. 5–8) can also be used during study design. With the goal of maximizing group differences, investigators may want to consider a certain workload where measurements are less likely to be obscured by measurement error. Similarly, if there is a standard exercise protocol, they may want to purchase a system that has high test–retest reliability in their typical range of workloads.

The current iteration of VO2sim is only able to assess the measurement error for one device, the Cosmed K4b^2. The reliability data for the Cosmed K4b^2 are reported for discrete volume measurements (e.g., VE = 45 L/min) and not as a continuous regression line (Duffield et al. 2004; Darter et al. 2013). This accounts for the visual grouping of results based upon the volume of gas measured (see Figs. 5–8). Future versions will support the assessment of other indirect calorimetry systems and will incorporate a continuous estimation of test–retest agreement. Future versions will also implement a graphical user interface to facilitate the use of VO2sim for researchers/clinicians not familiar with the R language.

4. References

Amann M, Goodall S, Twomey R, Subudhi AW, Lovering AT, Roach RC. AltitudeOmics: on the consequences of high-altitude acclimatization for the development of fatigue during locomotor exercise in humans. J Appl Physiol. 2013;115(5):634–642.

Atwater WO, Benedict FG. A respiration calorimeter with appliances for the direct determination of oxygen. Nutrition Reviews. 1983;41(11):353–356.

Borotikar BS, Newcomer R, Koppes R, McLean SG. Combined effects of fatigue and decision making on female lower limb landing postures: central and peripheral contributions to ACL injury risk. Clin Biomech. 2008;23(1):81–92.

Crouter SE, Antczak A, Hudak JR, DellaValle DM, Haas JD. Accuracy and reliability of the ParvoMedics TrueOne 2400 and MedGraphics VO2000 metabolic systems. Eur J Appl Physiol. 2006;98(2):139–151.

Darter BJ, Rodriguez KM, Wilken JM. Test–retest reliability and minimum detectable change using the K4b2: oxygen consumption, gait efficiency, and heart rate for healthy adults during submaximal walking. Res Q Exerc Sport. 2013;84(2):223–231.

Duffield R, Dawson B, Pinnington H, Wong P. Accuracy and reliability of a Cosmed K4b2 portable gas analysis system. J Sci Med Sport. 2004;7(1):11–22.

Gefen A. Biomechanical analysis of fatigue-related foot injury mechanisms in athletes and recruits during intensive marching. Med Biol Eng Comput. 2002;40(3):302–310.

Gregorczyk KN, Obusek JP, Hasselquist L, Bensel JMS, Carolyn K, Gutekunst D, Frykman P. The effects of a lower body exoskeleton load carriage assistive device on oxygen consumption and kinematics during walking with loads. Natick (MA): Army Natick Soldier Center (US); 2006.

LaFiandra M, Lynch S, Frykman P, Harman E, Ramos H. A comparison of the scorpion load carriage system (SLCS) to the modular lightweight load carrying equipment (MOLLE). Natick (MA): Army Research Institute of Environmental Medicine (US); 2003. Report No.: T-03/16.

Mair SD, Seaber AV, Glisson RR, Garrett WE. The role of fatigue in susceptibility to acute muscle strain injury. Am J Sports Med. 1996;24(2):137–143.

R Core Team. A language and environment for statistical computing. Vienna (Austria): R Foundation for Statistical Computing; 2014.

Self DA, Mandella JG, White VL, Burian D. Physiological determinants of human acute hypoxia tolerance. Oklahoma City (OK): FAA Civil Aerospace Medical Institute; 2013. Report No.: DOT/FAA/AM-13/22.

Weir JdV. New methods for calculating metabolic rate with special reference to protein metabolism. J Physiol. 1949;109(1–2):1–9.

Weyand P. Locomotion with loads: practical techniques for predicting performance outcomes. Ft. Detrick (MD): Army Medical Research and Materiel Command (US); 2013 May.

Appendix A. VO2sim Functions

This appendix appears in its original form, without editorial change.

VO2sim.repeat
#'a' is the base condition, 'b' is experimental.

```
VO2sim.repeat<- function(a, b, system='cosmed_k4b2'){
   a.round <- round(a, digits=2)
   b.round <- round(b, digits=2)
   if (system=='cosmed_k4b2'){
      if (a.round <= 0.5){
         a.min <- a.round*0.43
         a.max <- a.round*1.57
         a.dist <- round(runif(100000,min= a.min, max= a.max), digits=2)
      } else if (a.round>0.5 & a.round<1.0){
         a.min <- a.round*0.90
         a.max <- a.round*1.10
         a.dist <- round(runif(100000,min= a.min, max= a.max), digits=2)
      } else if (a.round>=1.0 & a.round<3.5){
         a.min <- a.round*0.85
         a.max <- a.round*1.15
         a.dist <- round(runif(100000,min= a.min, max= a.max), digits=2)
      } else if (a.round>= 3.5){
         a.min <- a.round*0.87
         a.max <- a.round*1.13
         a.dist <- round(runif(100000,min= a.min, max= a.max), digits=2)
      } else{
      print('I can not process data from systems other than Cosmed k4b2
at this time')
   }
   if (system =='cosmed_k4b2'){
      probsame <- (sum(a.dist == b.round)/100000)*100
      probhigh <- (sum(a.dist < b.round)/100000)*100
      problow <- (sum(a.dist > b.round)/100000)*100
      probs <- c(probsame, probhigh, problow)
      highest.prob <- probs[probs==max(probs)]
      if (highest.prob == probsame){
         print(paste0("There is a ", highest.prob, " probability that these
measures are the same VO2"))
      } else if (highest.prob == probhigh){
         print(paste0("There is a ", highest.prob, " probability that VO2 b is
greater than VO2 a"))
      } else if (highest.prob == problow){
         print(paste0("There is a ", highest.prob, " probability that VO2 b is
less than VO2 a"))
      }
      return(probs)
   }
}
```

VCO2sim.repeat

```
# a is the base condition, 'b' is experimental.
VCO2sim.repeat<- function(a, b, system='cosmed_k4b2'){
   a.round <- round(a, digits=2)
   b.round <- round(b, digits=2)
   if (system=='cosmed_k4b2'){
      if (a.round < 3.25){
         a.min <- a.round*0.81
         a.max <- a.round*1.19
         a.dist <- round(runif(100000,min= a.min, max= a.max), digits=2)
      } else if (a.round>= 3.25){
         a.min <- a.round*0.72
         a.max <- a.round*1.28
         a.dist <- round(runif(100000,min= a.min, max= a.max), digits=2)
      }
   else{
     print('I can not process data from systems other than Cosmed k4b2 at
this time')
   }

   if (system =='cosmed_k4b2'){
      probsame <- (sum(a.dist == b.round)/100000)*100
      probhigh <- (sum(a.dist < b.round)/100000)*100
      problow <- (sum(a.dist > b.round)/100000)*100
      probs <- c(probsame, probhigh, problow)
      highest.prob <- probs[probs==max(probs)]
      if (highest.prob == probsame){
         print(paste0("There is a ", highest.prob, " probability that these
measures are the same VCO2"))
      } else if (highest.prob == probhigh){
         print(paste0("There is a ", highest.prob, " probability that VO2 b is
greater than VCO2 a"))
      } else if (highest.prob == problow){
         print(paste0("There is a ", highest.prob, " probability that VO2 b is
less than VCO2 a"))
      }
      return(probs)
   }
}
```

VEsim.repeat

```
# a is the base condition, 'b' is experimental.
VEsim.repeat<- function(a, b, system='cosmed_k4b2'){
   a.round <- round(a, digits=2)
   b.round <- round(b, digits=2)
   if (system=='cosmed_k4b2'){
      if (a.round < 80.00){
         a.min <- a.round*0.88
         a.max <- a.round*1.12
         a.dist <- round(runif(100000,min= a.min, max= a.max), digits=2)
      } else if (a.round>= 80.00){
         a.min <- a.round*0.78
         a.max <- a.round*1.22
         a.dist <- round(runif(100000,min= a.min, max= a.max), digits=2)
      }
   else{
     print('I can not process data from systems other than Cosmed k4b2 at
this time')
   }

   if (system =='cosmed_k4b2'){
      probsame <- (sum(a.dist == b.round)/100000)*100
      probhigh <- (sum(a.dist < b.round)/100000)*100
      problow <- (sum(a.dist > b.round)/100000)*100
      probs <- c(probsame, probhigh, problow)
      highest.prob <- probs[probs==max(probs)]
      if (highest.prob == probsame){
         print(paste0("There is a ", highest.prob, " probability that these
measures are the same VE"))
      } else if (highest.prob == probhigh){
         print(paste0("There is a ", highest.prob, " probability that VO2 b is
greater than VE a"))
      } else if (highest.prob == problow){
         print(paste0("There is a ", highest.prob, " probability that VO2 b is
less than VE a"))
      }

      return(probs)
   }
}
```

Appendix B. R Markdown File

VO2sim Technical Note

Matthew S. Tenan, PhD ATC

Wednesday, March 18, 2015

This is the R Markdown document detailing the use of VO2sim.repeat and creating the figures for the technical note.

Install VO2sim package and place it in library + load ggplot2 for graphing

```
setwd("L:/Biomechanics/VO2sim/VO2sim")

install.packages("devtools", repos= "http://cran.rstudio.com/")

## Installing package into 'C:/Users/matthew.s.tenan/Documents/R/win-library/
3.1'
## (as 'lib' is unspecified)

## package 'devtools' successfully unpacked and MD5 sums checked
##
## The downloaded binary packages are in
##   C:\Users\matthew.s.tenan\AppData\Local\Temp\RtmpKae3C6\downloaded_package
s

install.packages('gridExtra', repos = "http://cran.rstudio.com/")

## Installing package into 'C:/Users/matthew.s.tenan/Documents/R/win-library/
3.1'
## (as 'lib' is unspecified)

## package 'gridExtra' successfully unpacked and MD5 sums checked
##
## The downloaded binary packages are in
##   C:\Users\matthew.s.tenan\AppData\Local\Temp\RtmpKae3C6\downloaded_package
s

library(gridExtra)

## Loading required package: grid

library("devtools")

## WARNING: Rtools is required to build R packages, but is not currently inst
alled.
```

```
##
## Please download and install Rtools 3.1 from http://cran.r-project.org/bin/
windows/Rtools/ and then run find_rtools().

install('VO2sim')

## Installing VO2sim
## "C:/PROGRA~1/R/R-31~1.2/bin/x64/R" --vanilla CMD INSTALL  \
##   "L:/Biomechanics/VO2sim/VO2sim"  \
##   --library="C:/Users/matthew.s.tenan/Documents/R/win-library/3.1"  \
##   --install-tests

library('VO2sim')
library('ggplot2')
```

Creation of example plots to demonstrate how VO2sim.repeat works

Simulate Data

```
set.seed(71185)
dist.x <- as.data.frame(round(runif(100000, min= 1.275, max= 1.725), digits=2
))
colnames(dist.x) <- 'sim_con'
```

Plots 1 & 2

```
ggplot(dist.x, aes(x = sim_con)) +
    geom_histogram(colour = "black", fill = "darkgreen", binwidth = .01) +
    theme_bw() +
    xlab('Simulated VO2 for Second Control Session (L/min)') +
    ylab('Count') +
    ylim(0, 3000)
```
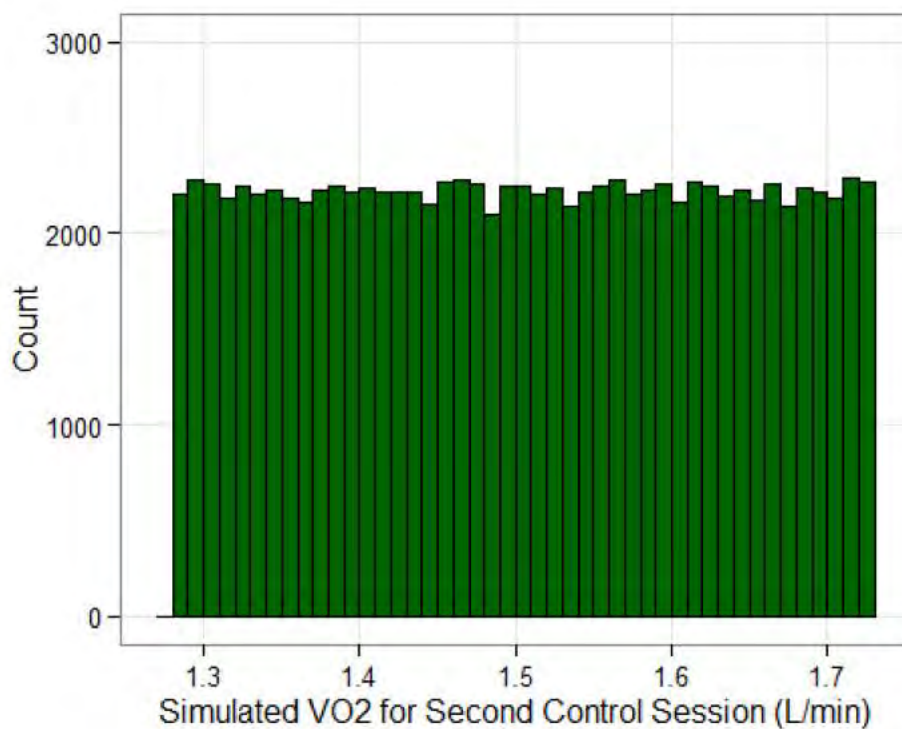
Plot 3

```r
ggplot(dist.x, aes(x = sim_con)) +
  geom_histogram(colour = "black", binwidth = .01, aes(fill = (sim_con==1.55)
)) +
  scale_fill_manual(values=c('FALSE'='darkgreen', 'TRUE'='firebrick')) +
  theme_bw() +
  xlab('Simulated VO2 for Second Control Session (L/min)') +
  ylab('Count') +
  ylim(0, 3000) +
  scale_color_identity() +
  theme(legend.position="none")
```
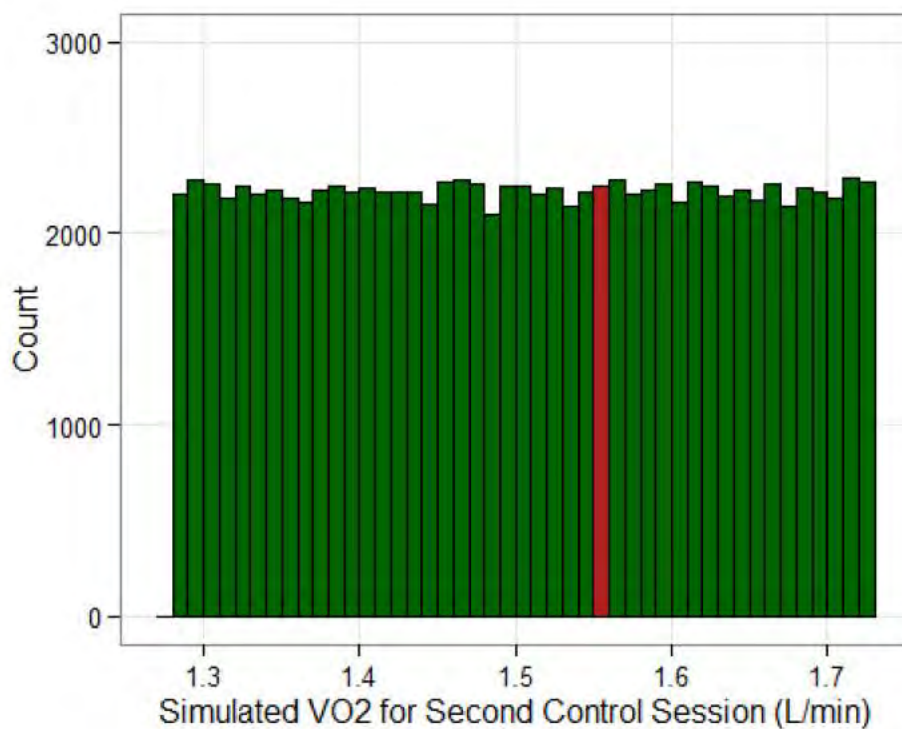
Plot 4

```
ggplot(dist.x, aes(x = sim_con)) +
  geom_histogram(colour = "black", binwidth = .01, aes(fill = (sim_con==1.38)
)) +
  scale_fill_manual(values=c('FALSE'='darkgreen', 'TRUE'='firebrick')) +
  theme_bw() +
  xlab('Simulated VO2 for Second Control Session (L/min)') +
  ylab('Count') +
  ylim(0, 3000) +
  scale_color_identity() +
  theme(legend.position="none")
```

Simulated VO2 for Second Control Session (L/min)
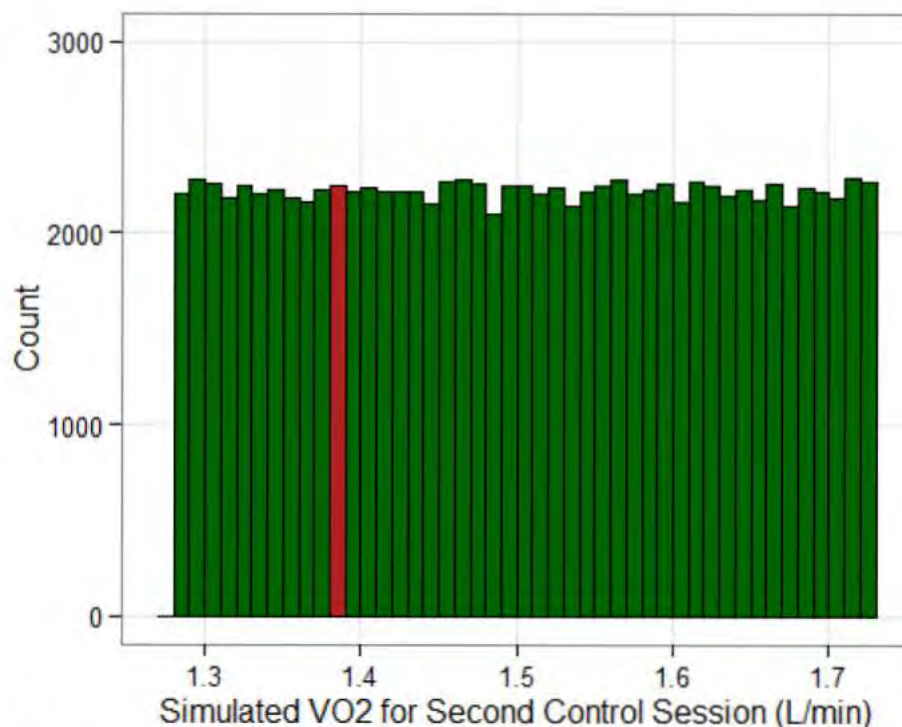
Creating Data and Plot 5

```
###Creation of data for figure 5, 3% increase in VO2
control <- seq(from=0.01, to = 4.5, by = 0.01)
exp <- control*1.03
#Run VO2sim
fig5dat <- Map(VO2sim.repeat, a=control, b=exp)

## [1] "There is a 87.718 probability that these measures are the same VO2"
## [1] "There is a 43.869 probability that these measures are the same VO2"
## [1] "There is a 35.604 probability that VO2 b is greater than VO2 a"
## [1] "There is a 39.157 probability that VO2 b is greater than VO2 a"
## [1] "There is a 41.284 probability that VO2 b is greater than VO2 a"
## [1] "There is a 42.769 probability that VO2 b is less than VO2 a"
## [1] "There is a 43.77 probability that VO2 b is less than VO2 a"
## [1] "There is a 44.54 probability that VO2 b is greater than VO2 a"
## [1] "There is a 45.339 probability that VO2 b is less than VO2 a"
## [1] "There is a 45.77 probability that VO2 b is less than VO2 a"
## [1] "There is a 46.125 probability that VO2 b is greater than VO2 a"
## [1] "There is a 46.61 probability that VO2 b is less than VO2 a"
## [1] "There is a 46.668 probability that VO2 b is less than VO2 a"
## [1] "There is a 47.063 probability that VO2 b is greater than VO2 a"
## [1] "There is a 47.329 probability that VO2 b is greater than VO2 a"
## [1] "There is a 47.326 probability that VO2 b is less than VO2 a"
## [1] "There is a 52.852 probability that VO2 b is greater than VO2 a"
## [1] "There is a 52.284 probability that VO2 b is greater than VO2 a"
## [1] "There is a 52.094 probability that VO2 b is greater than VO2 a"
```

```
## [1] "There is a 52.229 probability that VO2 b is greater than VO2 a"
## [1] "There is a 52.037 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.892 probability that VO2 b is greater than VO2 a"
## [1] "There is a 52.153 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.719 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.585 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.691 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.594 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.447 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.344 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.754 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.194 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.34 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.177 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.271 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.502 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.335 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.271 probability that VO2 b is greater than VO2 a"
## [1] "There is a 50.992 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.039 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.196 probability that VO2 b is greater than VO2 a"
## [1] "There is a 51.534 probability that VO2 b is greater than VO2 a"
## [1] "There is a 50.967 probability that VO2 b is greater than VO2 a"
## [1] "There is a 50.98 probability that VO2 b is greater than VO2 a"
## [1] "There is a 50.994 probability that VO2 b is greater than VO2 a"
## [1] "There is a 50.97 probability that VO2 b is greater than VO2 a"
## [1] "There is a 50.69 probability that VO2 b is greater than VO2 a"
## [1] "There is a 50.827 probability that VO2 b is greater than VO2 a"
## [1] "There is a 50.743 probability that VO2 b is greater than VO2 a"
## [1] "There is a 50.926 probability that VO2 b is greater than VO2 a"
## [1] "There is a 52.648 probability that VO2 b is greater than VO2 a"
## [1] "There is a 64.697 probability that VO2 b is greater than VO2 a"
## [1] "There is a 64.599 probability that VO2 b is greater than VO2 a"
## [1] "There is a 64.186 probability that VO2 b is greater than VO2 a"
## [1] "There is a 63.862 probability that VO2 b is greater than VO2 a"
## [1] "There is a 63.996 probability that VO2 b is greater than VO2 a"
## [1] "There is a 63.633 probability that VO2 b is greater than VO2 a"
## [1] "There is a 62.914 probability that VO2 b is greater than VO2 a"
## [1] "There is a 62.785 probability that VO2 b is greater than VO2 a"
## [1] "There is a 62.827 probability that VO2 b is greater than VO2 a"
## [1] "There is a 62.508 probability that VO2 b is greater than VO2 a"
## [1] "There is a 62.216 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.929 probability that VO2 b is greater than VO2 a"
## [1] "There is a 62.008 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.702 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.732 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.277 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.293 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.016 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.91 probability that VO2 b is greater than VO2 a"
```

```
## [1] "There is a 60.858 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.275 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.711 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.22 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.118 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.006 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.9 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.582 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.892 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.463 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.203 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.471 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.099 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.15 probability that VO2 b is greater than VO2 a"
## [1] "There is a 64.953 probability that VO2 b is greater than VO2 a"
## [1] "There is a 64.599 probability that VO2 b is greater than VO2 a"
## [1] "There is a 64.569 probability that VO2 b is greater than VO2 a"
## [1] "There is a 64.336 probability that VO2 b is greater than VO2 a"
## [1] "There is a 64.424 probability that VO2 b is greater than VO2 a"
## [1] "There is a 64.374 probability that VO2 b is greater than VO2 a"
## [1] "There is a 64.153 probability that VO2 b is greater than VO2 a"
## [1] "There is a 63.953 probability that VO2 b is greater than VO2 a"
## [1] "There is a 63.25 probability that VO2 b is greater than VO2 a"
## [1] "There is a 63.382 probability that VO2 b is greater than VO2 a"
## [1] "There is a 63.232 probability that VO2 b is greater than VO2 a"
## [1] "There is a 63.178 probability that VO2 b is greater than VO2 a"
## [1] "There is a 63.138 probability that VO2 b is greater than VO2 a"
## [1] "There is a 62.793 probability that VO2 b is greater than VO2 a"
## [1] "There is a 62.891 probability that VO2 b is greater than VO2 a"
## [1] "There is a 62.666 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.378 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.023 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.212 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.924 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.066 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.945 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.153 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.819 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.433 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.505 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.287 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.764 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.438 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.405 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.106 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.127 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.043 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.881 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.907 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.061 probability that VO2 b is greater than VO2 a"
```

```
## [1] "There is a 59.657 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.468 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.657 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.548 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.598 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.551 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.303 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.095 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.31 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.905 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.897 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.723 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.807 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.752 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.883 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.685 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.676 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.417 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.593 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.306 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.313 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.002 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.255 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.127 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.127 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.985 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.016 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.096 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.099 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.765 probability that VO2 b is greater than VO2 a"
## [1] "There is a 57.712 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.019 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.815 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.056 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.872 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.561 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.896 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.532 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.722 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.243 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.352 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.27 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.162 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.177 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.115 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.107 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.903 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.975 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.993 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.976 probability that VO2 b is greater than VO2 a"
```

```
## [1] "There is a 58.919 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.728 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.946 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.668 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.709 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.402 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.308 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.011 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.391 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.13 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.366 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.202 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.246 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.145 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.147 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.807 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.957 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.633 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.536 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.547 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.593 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.422 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.37 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.576 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.371 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.604 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.211 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.391 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.142 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.115 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.996 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.008 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.259 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.18 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.952 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.771 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.982 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.922 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.808 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.734 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.947 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.016 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.769 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.848 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.807 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.518 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.714 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.031 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.887 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.753 probability that VO2 b is greater than VO2 a"
```

```
## [1] "There is a 59.503 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.865 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.023 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.723 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.67 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.709 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.552 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.379 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.554 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.202 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.431 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.469 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.543 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.558 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.165 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.495 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.251 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.016 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.179 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.787 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.145 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.342 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.947 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.862 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.645 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.887 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.801 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.948 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.968 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.406 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.01 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.775 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.892 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.848 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.128 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.855 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.803 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.841 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.766 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.742 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.635 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.704 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.712 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.579 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.409 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.38 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.222 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.706 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.183 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.438 probability that VO2 b is greater than VO2 a"
```

```
## [1] "There is a 59.537 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.195 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.145 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.179 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.815 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.991 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.939 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.203 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.936 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.058 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.262 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.856 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.994 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.602 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.975 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.933 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.935 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.706 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.533 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.96 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.718 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.653 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.783 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.84 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.029 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.543 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.813 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.551 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.239 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.513 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.179 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.22 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.46 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.319 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.369 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.388 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.26 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.395 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.125 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.104 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.487 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.095 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.085 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.786 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.925 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.078 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.853 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.811 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.725 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.909 probability that VO2 b is greater than VO2 a"
```

```
## [1] "There is a 59.887 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.727 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.682 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.005 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.947 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.721 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.931 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.779 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.586 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.671 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.524 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.419 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.635 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.247 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.583 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.531 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.58 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.359 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.339 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.314 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.343 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.279 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.02 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.761 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.156 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.154 probability that VO2 b is greater than VO2 a"
## [1] "There is a 58.951 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.067 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.052 probability that VO2 b is greater than VO2 a"
## [1] "There is a 59.249 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.355 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.429 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.268 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.291 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.259 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.475 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.471 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.322 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.325 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.413 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.199 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.344 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.262 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.952 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.194 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.094 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.119 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.952 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.787 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.786 probability that VO2 b is greater than VO2 a"
```

```
## [1] "There is a 60.682 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.84 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.771 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.743 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.356 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.919 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.515 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.649 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.587 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.646 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.614 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.441 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.604 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.466 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.66 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.481 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.38 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.594 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.443 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.352 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.318 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.363 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.295 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.105 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.802 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.334 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.45 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.547 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.21 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.971 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.93 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.892 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.275 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.809 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.915 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.945 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.061 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.628 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.934 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.605 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.965 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.66 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.537 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.439 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.601 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.65 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.637 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.574 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.54 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.522 probability that VO2 b is greater than VO2 a"
```

```
## [1] "There is a 61.379 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.345 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.43 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.426 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.314 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.121 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.505 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.703 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.045 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.988 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.821 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.101 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.128 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.053 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.891 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.013 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.216 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.233 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.89 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.146 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.88 probability that VO2 b is greater than VO2 a"
## [1] "There is a 61.062 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.871 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.745 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.749 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.968 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.527 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.792 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.765 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.625 probability that VO2 b is greater than VO2 a"
## [1] "There is a 60.853 probability that VO2 b is greater than VO2 a"

fig5dat <- as.data.frame(do.call(rbind, fig5dat))
colnames(fig5dat) <- c('same', 'higher', 'lower')
fig5dat <- cbind(fig5dat, as.data.frame(exp))
##Create plots for figure 5
#Same plot
same.3 <- ggplot(fig5dat, aes(x=exp, y=same)) +
        geom_point() +
        theme_bw() +
        ylab('Probability that Experimental Value is Identical to Control
') +
        xlab('Experimental Value (L/min)') +
        ylim(0,100)

#Higher Plot
higher.3 <- ggplot(fig5dat, aes(x=exp, y=higher)) +
        geom_point() +
        theme_bw() +
        ylab('Probability that Experimental Value is Greater Than Contr
```

```
ol') +
            xlab('Experimental Value (L/min)')+
            ylim(0,100)

#Lower Plot
lower.3 <- ggplot(fig5dat, aes(x=exp, y=lower)) +
            geom_point() +
            theme_bw() +
            ylab('Probability that Experimental Value is Less Than Control'
) +
            xlab('Experimental Value (L/min)') +
            ylim(0,100)

#make figure 5
grid.arrange(same.3,higher.3,lower.3, ncol=3)
```

1   ARMY RSCH LAB – HRED
(PDF)   HQ USASOC
        RDRL HRM CN   R SPENCER
        BLDG E2929 DESERT STORM DR
        FORT BRAGG NC 28310

1   ARMY G1
(PDF)   DAPE MR   B KNAPP
        300 ARMY PENTAGON
        RM 2C489
        WASHINGTON DC 20310-0300

        ABERDEEN PROVING GROUND

12   DIR USARL
(PDF)   RDRL HR
          L ALLENDER
          P FRANASZCZUK
          K MCDOWELL
        RDRL HRM
          P SAVAGE-KNEPSHIELD
        RDRL HRM AL
          C PAULILLO
        RDRL HRM B
          J GRYNOVICKI
        RDRL HRM C
          L GARRETT
        RDRL HRS
          J LOCKETT
        RDRL HRS B
          M LAFIANDRA
          M TENAN
        RDRL HRS D
          A SCHARINE
        RDRL HRS E
          D HEADLEY

36